CHAPTER

2

MULTILATERATION SYSTEM FOR POSITION ESTIMATION

Yaro Abdulmalik Shehu and Ahmad Zuri Sha'ameri

2.1 INTRODUCTION

A wireless positioning system utilizes aircraft transponder emissions detected at the antenna of a Ground Receiving Station (GRS) to determine the position of the aircraft. It is a two-stage process (Duran et al., 2012). The first stage involves the estimation of a position-dependent signal parameter from the received transponder emission, such as Angle of Arrival (AOA), Time of Arrival (TOA), Time Difference of Arrival (TDOA) and Receives Signal Strength (RSS). In the second stage, the position-dependent signal parameter estimated from the first stage is used as an input to a Position Estimation (PE) algorithm such as angulation, fingerprinting and lateration to determine the position of the aircraft. Figure 2.1 shows the structure of a wireless positioning system consisting of four GRSs connected to a Central Processing Station (CPS). The two stages used in determining the position of an aircraft from its transponder emission by the wireless positioning system take place in the CPS. Figure 2.2 shows the two stages of the positioning performed in the CPS by the wireless positioning system.

Air Traffic Monitoring (ATM) centers use the wireless positioning system for aircraft surveillance purposes. This involves directing and controlling air traffic within a Flight Information Region (FIR). The different types of surveillance technologies are grouped and summarized in Figure 2.3.

Surveillance radar which consists of Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) is the main surveillance technology used by the ATM centre. The PSR compares the difference between the transmitted pulse and the return pulse from the aircraft to estimate the aircraft range and azimuth (ICAO, 2001). The SSR was introduced to determine the altitude and aircraft identity. The aircraft equipped with a transponder transmits a coded reply signal (at 1090 MHz) as a response to interrogation (at 1030 MHz) by the ground component of the system. The type of code reply depends on the SSR mode of operation, that is, Mode A, Mode C, Mode S (ICAO, 2001).

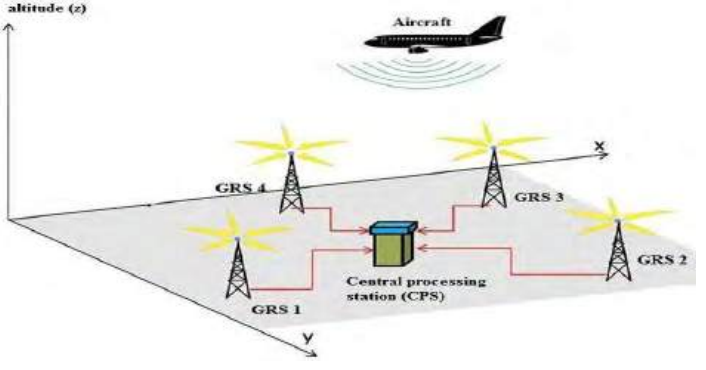

Figure 2.1 Structure of a wireless position system

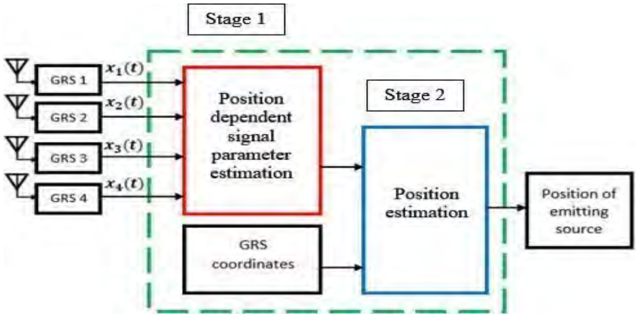

Figure 2.2 Stages of wireless positioning system formed in central processing station

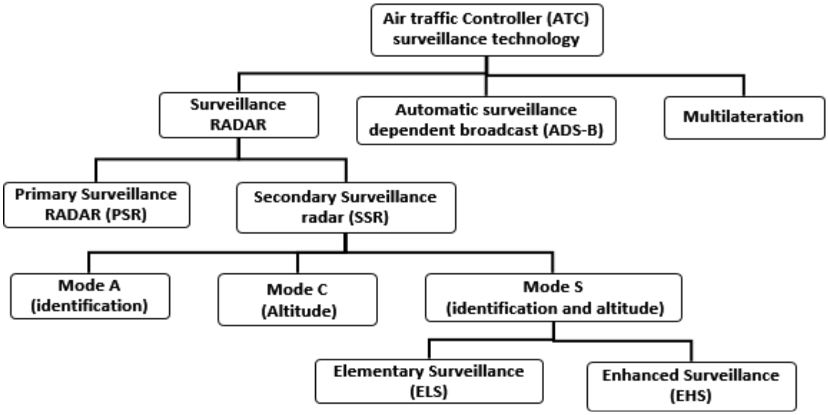

Figure 2.3 Air traffic controller surveillance technologies (ICAO, 2001)

ADS-B is an emerging surveillance technology for air traffic monitoring. This surveillance technology was introduced to meet the global traffic demand and mandates have been given to all airline operators to adopt ADS-B technology by the year 2020 (ICAO, 2001). An aircraft is equipped with a special type of transponder which it uses to determine its position using the Global Positioning System (GPS) and periodically broadcasts it along with other information such as aircraft ID to the ATM centre (ICAO, 2001). The system does not require any pilot input and thus 'automatic'. It is 'dependent' on the aircraft navigation system.

Another emerging surveillance system is multilateration which determines the position of aircraft using the TDOA. This system was introduced to increase air traffic surveillance coverage range which SSR or ADS-B cannot cover. The position of an aircraft is located by measuring the time difference of its transponder emission (Mode A, Mode C, Mode S or ADS-B) detected at two GRSs (ICAO, 2001). Its system consists of multiple spatially placed GRSs connected to a CPS via a communication data link to estimate the position of the aircraft (ICAO, 2001). The position of the aircraft can be estimated in two-dimensional (2D) or three-dimensional (3D) depending on the number of GRSs deployed (Neven et al., 2005). For a 3D aircraft position estimate, a minimum of four GRSs are required.